Development of a Life Detector for Planetary Soils
(Final Report for NsG-19-59)

1. During earlier phases of the work conducted under this grant a device was designed and built which was capable of detecting living organisms when placed on soil or on the laboratory floor. This report deals primarily with the final laboratory version of this device which was completed between June 1960 and August 1961. In principle the device operates by introducing dust samples into one or more selected media in which the growth of microorganisms is detected by optical and chemical changes in the medium. The following sections will discuss the particular problems encountered and the solutions used.

Sampling: In order to minimize the power requirements of the instrument it was decided to use a vacuum technique for the introduction of the sample. A vacuum chamber was placed on top of the instrument package and connected to the outside through the culture tube and intake mechanism. The intake mechanism was composed of a series of valves which were actuated by impact, and an internal check valve to prevent the evaporation of liquid media should the outside partial pressure of water be low, a control of the rate of air flow, and an external closure which consisted of a standard taper glass cap over the end of the intake which was ground to a standard taper. The vacuum chamber could be pumped out and closed, and it would maintain its ability to draw in a dust sample until needed. The enclosed photographs show the general arrangement of the instrument (see reprint for details).

Medium: Although the incorporation of liquid media into a device of this sort presents problems which the use of solid media would not, a quantitative measure of growth is easier in a liquid medium. It was decided, therefore, to use liquid rather than solid culture media. The choice of media was governed by the ideas which were set forth in the paper "Extraterrestrial Microbiology", Aerospace Medicine, 31, 678, 1960. Since according to our present understanding Mars is an Oxygen free planet, the media must provide for those organisms which would maintain a balanced ecology under anaerobic conditions. Accordingly the media were designed for organisms which fill the major anaerobic ecologic niches. The media selected therefore are those that would support the growth of (a) photosynthetic bacteria, (b) sulfate reducing bacteria, (c) nitrate reducing bacteria, (d) methane forming bacteria, (e) putrifactive bacteria such as Clostridium.

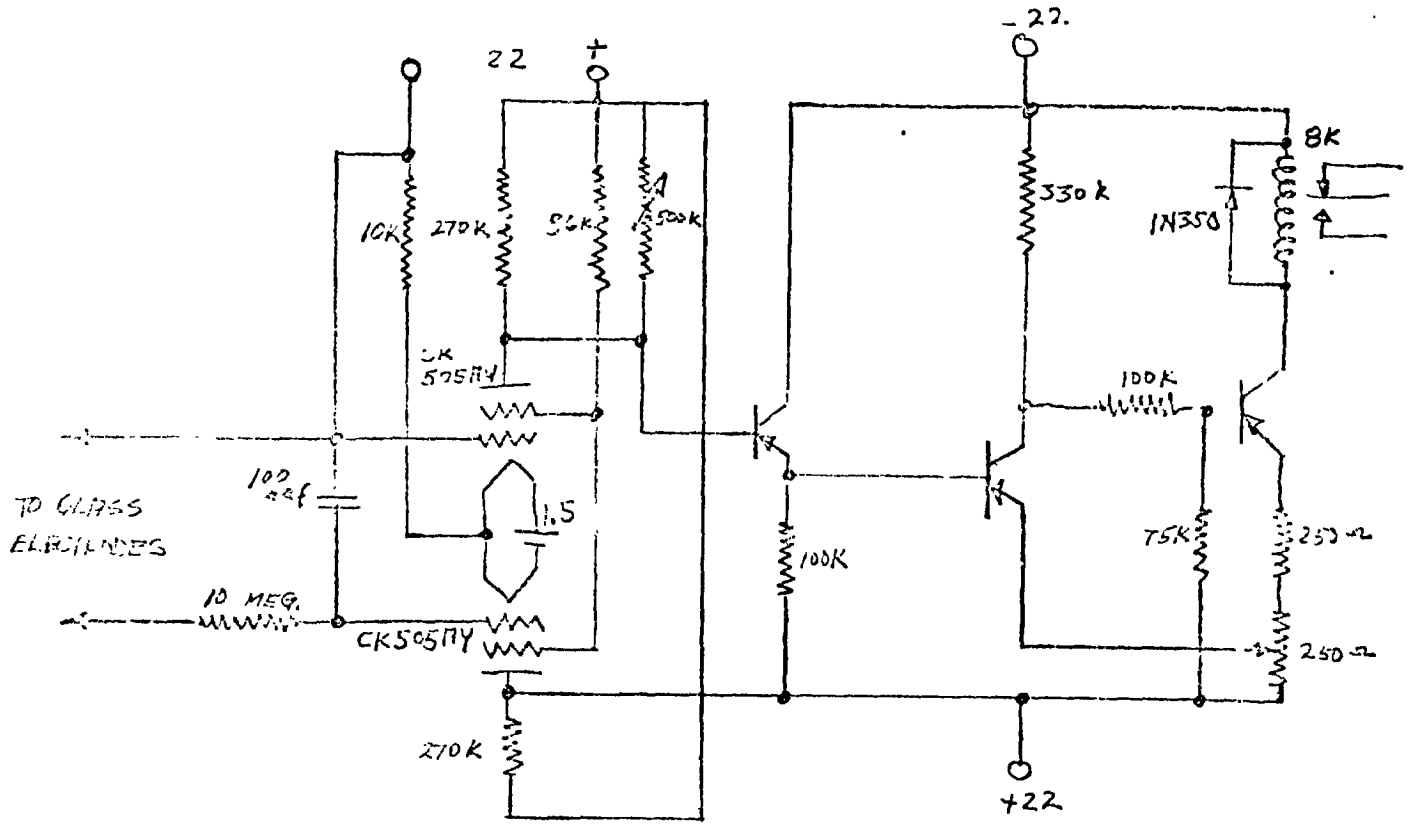
Detection: The growth of microorganisms brings about changes in the medium which are a measure of the growth which has taken place. The two changes that were selected for this instrument were change in light transmission and pH. The lower end of the culture tube was interposed in a path between a light source and a light detecting circuit. A combination pH electrode was inserted into the culture tube. The circuits for the light detection and pH measurement are shown on the enclosed sketches. The instrument could be adjusted to respond to a selected magnitude of change in optical properties or in pH. An increase in optical density above a certain limit, or an increase or decrease in pH beyond certain limits cause the closure of a relay which in turn activated another signal, in this case a signal lamp.

Performance: Laboratory tests were performed by charging the instrument with a medium consisting either of 0.2% yeast extract or the same medium plus 0.3% glucose. The instrument was adjusted to detect a turbidity that would correspond to 10^7 microorganisms per ml. and to a change in pH of 0.5 units either above or below the pH of the original medium. The medium was adjusted to pH 7.0, and the culture tube and connected parts of the instrument sterilized by heat. The sterilized components were assembled into the complete instrument, the vacuum chamber was pumped out, and the instrument placed on the floor. The figures in the table below give the time in hours after "impact" after which time the signal light indicated a significant change in turbidity or pH. It can be seen that, as expected, the medium suplemented with glucose evoked a response earlier than the medium containing yeast extract alone. On yeast extract alone, the pH signal went on several hours after the turbidity had increased. The pH in these media had risen to between 7.5 and 8.0. In the medium containing glucose the pH dropped rapidly, and the pH change was signaled before a large increase in turbidity had taken place. In these media the pH had dropped to well below 5.5, presumably due to the formation of fermentation acids.

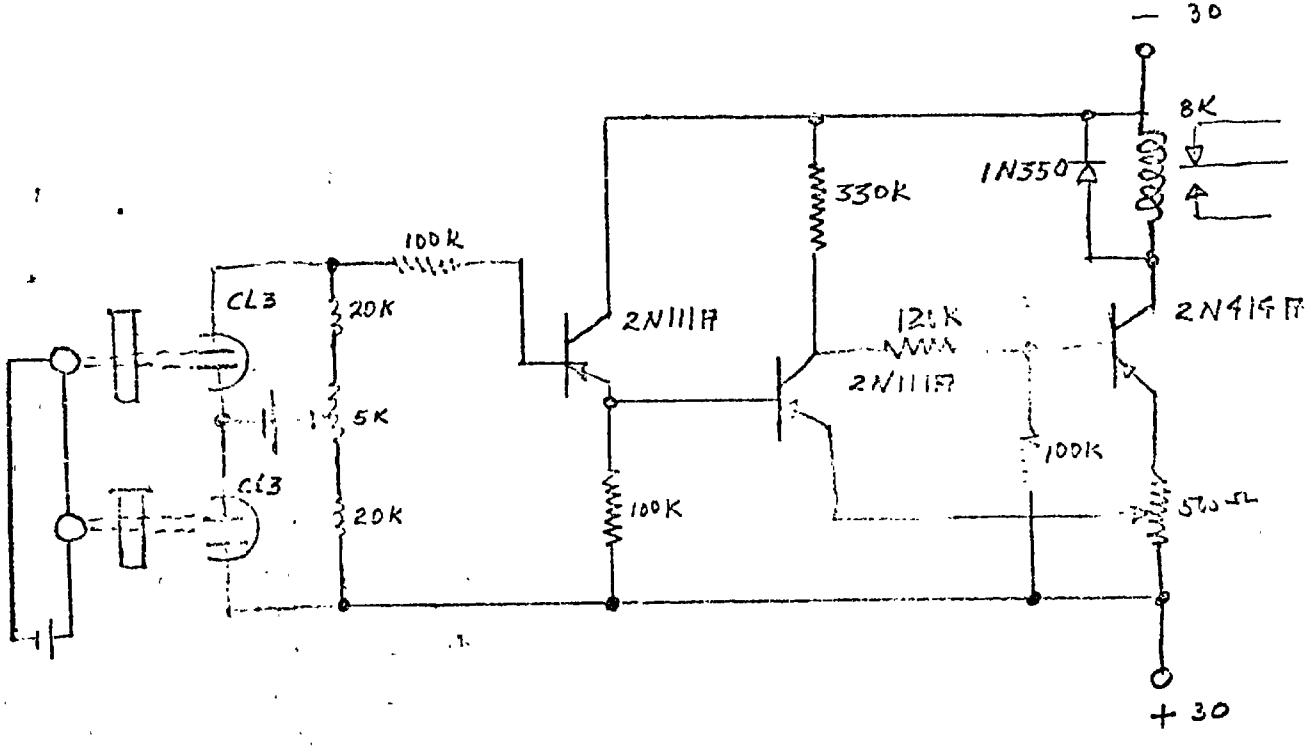
2. Further Problems: The refinement of this instrument is now mostly a matter of engineering development, although additional laboratory tests will of course be carried out. Primarily the instrument must be redesigned so that complete sterilization is possible even of the electrical components, and the mechanical features must be commensurate with the requirements of space vehicle launching. Major changes in the instrument design will include: measurement of light scattering instead of transmission in order to increase the sensitivity of the instrument, and continuous (or at least repeated) measurements of changes rather than a single determination when a particular level has been exceeded.

Table showing time in hours after "impact", i.e. placing the instrument on the laboratory floor, at which signals indicated a significant increase in turbidity or change in pH

Change Observed / Medium Used	Turbidity	pH
0.2% yeast extract	7 8 5	9 9 7
0.2% yeast extract + 0.3% glucose	5 6 6	4 6 5



PH MEASURING CIRCUIT 7-5-1



PHOTOMETRIC
DETECTOR 7-5-60